

# **Lake Okeechobee**

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## **Supply-Side**

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# **Management Plan**



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## **TABLE OF CONTENTS**

	<b><u>Page</u></b>
<b>I. Introduction</b>	<b>1</b>
<b>II. Hydrology Of Water Shortages</b>	
<b>A. The Hydrologic Cycle</b>	<b>1</b>
<b>B. Precipitation</b>	<b>2</b>
<b>C. Evaporation And Evapotranspiration</b>	<b>3</b>
<b>D. Supplemental Water Use</b>	
1. Agricultural	4
2. Urban	4
3. Environmental	5
<b>E. Supplies And Storage</b>	<b>5</b>
<b>III. Lake Okeechobee</b>	
<b>A. Reservoir</b>	<b>5</b>
<b>B. Management Zones</b>	<b>6</b>
<b>C. Service Area</b>	<b>7</b>
<b>IV. Water Shortage Plan</b>	<b>7</b>
<b>V. Supply-Side Management</b>	
<b>A. Philosophy And Concepts</b>	<b>8</b>
<b>B. Historic Application</b>	<b>8</b>
<b>C. Computation Procedures</b>	
1. Dry Season	9
2. Monthly Allocations	9
<b>D. Allocation Factors</b>	
1. Normal Monthly	12
2. Borrowed Monthly	12
3. Normal Weekly	13
<b>E. Other Factors</b>	<b>16</b>
<b>VI. Summary</b>	<b>17</b>

### LIST OF FIGURES

	<u>Page</u>
<b>Figure 1 - EAA Annual Rainfall Variation From Mean</b>	<b>2</b>
<b>Figure 2 - EAA Hydrologic Parameters</b>	<b>3</b>
<b>Figure 3 - Actual vs. Estimated Use</b>	<b>4</b>
<b>Figure 4 - Management Zones</b>	<b>6</b>

### LIST OF TABLES

	<u>Page</u>
<b>Table 1 - Lake Okeechobee Service Area Basins</b>	<b>7</b>
<b>Table 2 - Monthly Distribution of Hydrologic Factors</b>	<b>10</b>
<b>Table 3 - Normal Monthly Allocation Factors</b>	<b>12</b>
<b>Table 4 - Allocation Factors - November Borrowing</b>	<b>13</b>
<b>Table 5 - Normal Weekly Allocation Factors 1990/91</b>	<b>14</b>
<b>Table 6 - Sub-basin Irrigated Acreage And Control Structure</b>	<b>16</b>

## I. INTRODUCTION

The Lake Okeechobee Supply-Side Management Plan is designed to manage supply and demand for water users within the Lake Okeechobee Service Area and the Lower East Coast of Florida. The management of regional water supplies in south Florida required the establishment of a procedure for supply allocation during periods of shortage. The climate of the area has had such a wide variation of precipitation amounts over the past ten years that water shortages have necessitated implementation of use restrictions in half of these years. When supplies and precipitation were plentiful, little concern for use and distribution existed, however when the rains stopped and storage levels fell, much interest in the water use issues arose.

In order to best manage a limited surface water supply, the District needed a method for allocation which recognized the need to hold water in reserve for anticipated high-demand periods. The method also must be flexible and responsive enough to allow for short-term fluctuations of supply and demand. The method developed includes consideration of all of these factors plus the actual physical limitations of the delivery system.

## II. HYDROLOGY OF WATER SHORTAGES

### A. THE HYDROLOGIC CYCLE

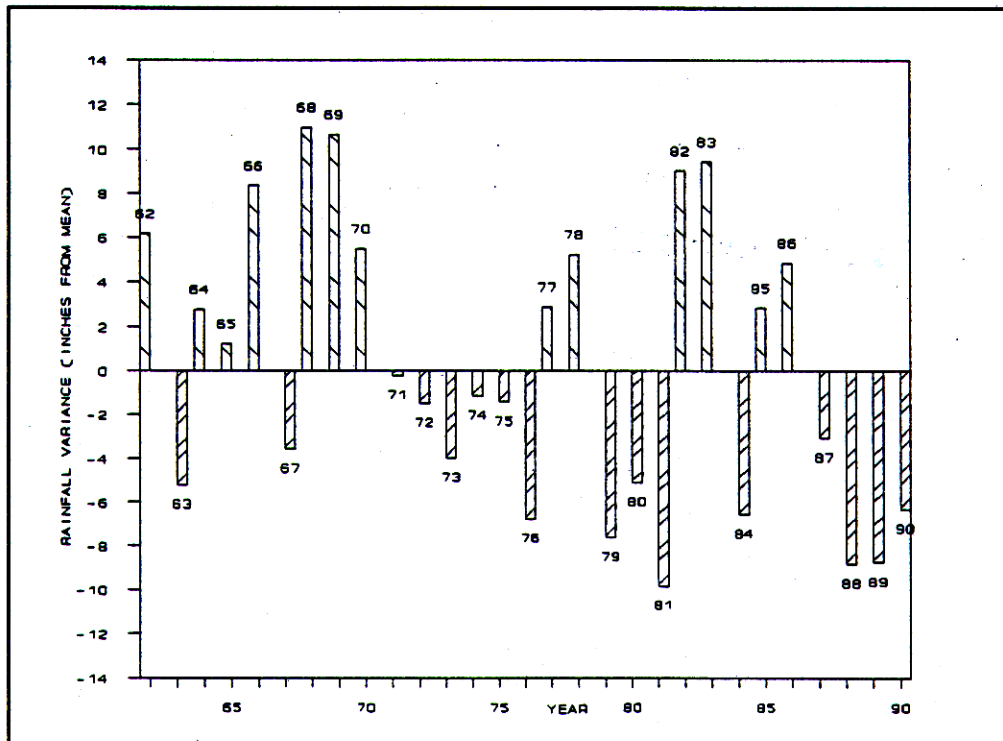
The term, hydrologic cycle, is commonly used to describe the cyclical process of water transfer as it moves from the atmosphere to the ground and back again. The major components are rainfall, runoff, evapotranspiration and seepage. When dealing with a surface reservoir system, the additional components of inflow, outflow and storage are also considered. In the development of a water allocation scheme for the Lake Okeechobee Service Area certain components of significance were selected in order to simplify modeling and related computations. These components are described and quantified in subsequent sections.

In addition, some concepts which warrant special treatment are effective rainfall, supplemental water needs and the statistical frequency of demands. The estimation of plant water requirements requires consideration of both the magnitude and the "effectiveness" of rainfall. Specifically, when it rains too hard, at a rate greater than the plant can use and/or the ground can absorb it, some portion becomes runoff and is discharged from the area. The amount of rain that falls at a rate that is less than or equal to the plant requirements is termed, effective rainfall. Therefore, ignoring seepage losses, it can be stated that, on an average annual basis, the effective rainfall can be approximated by subtracting the annual runoff from the annual rainfall of a watershed. Rainfall and plant water requirements vary from month to month and since the variation is rarely coincident supplemental water must be added to meet the crop requirements periodically.

Due to the size and extent of the District water control system, some areas and user groups may not require water from Lake Okeechobee every year. For example, the Everglades Agricultural Area(EAA) requires supplemental irrigation water from the lake yearly, but the Lower East Coast(LEC) urban users may only need to tap the lake as a source every three to four years. An additional factor which affects water needs is the predominant soil type of an area. The EAA is predominantly muck, whereas, the St.Lucie Canal Basin is almost entirely deep-drained sands, which require additional water for irrigation because of seepage losses.

## **B. PRECIPITATION**

The average annual rainfall in the Everglades Agricultural Area from 1962 to 1990 was 49.0 inches, see Table A1 in the Appendix. The actual annual rainfalls for each year exhibited very wide deviations from this average, however. The variation from mean for the individual years is shown in Figure 1. The most recent past has seen four consecutive years of significantly below normal rainfall. From a water demand standpoint the annual deficits are not cumulative in their impacts because the life span of crops is less than one year. However, from a regional water storage and supply perspective their effects are cumulative and problematic.



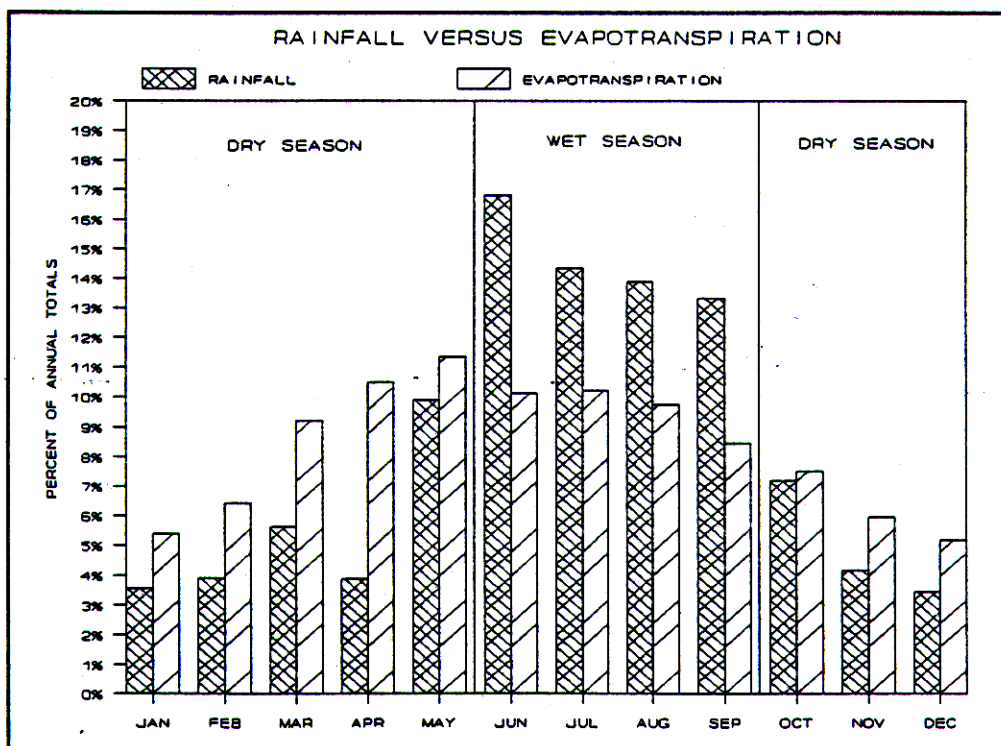
**Figure 1 - EAA Annual Rainfall Variation From Mean**



The seasonal and monthly variations of rainfall are the most significant from a demand management perspective. The majority of the rainfall occurs in the four summer months of June to September, with the balance occurring in the eight-month dry season. The EAA is referred to as the "winter vegetable capitol" which is indicative of the high anticipated demands which occur in the late fall to early spring timeframe.

### C. EVAPORATION AND EVAPOTRANSPIRATION

The average annual pan evaporation measured at Belle Glade from 1970 to 1990 was 61.6 inches, see Table A2 in the Appendix. In order to convert pan data to lake evaporation and plant evapotranspiration pan coefficients are used. For Lake Okeechobee a pan coefficient of 0.80, and for the EAA an average crop coefficient of 0.65, is used herein. Applying these coefficients the average lake evaporation during this period would have been 49.3 inches and the average evapotranspiration would have been 40.0 inches. The monthly distribution of evapotranspiration, as shown in Figure 2, shows that the majority of the evapotranspiration, 62%, occurs in the dry season of October to May, whereas the majority of the rain, 58%, falls from June to September.



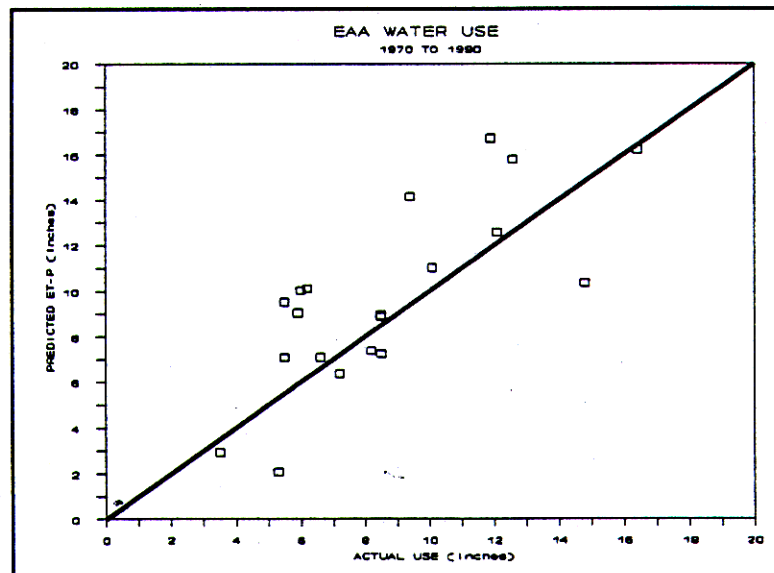
**Figure 2 - EAA Hydrologic Parameters**

## D. SUPPLEMENTAL WATER USE

### **1. AGRICULTURAL**

The supplemental irrigation requirements for crops in the EAA and the adjacent service areas of the Caloosahatchee and St. Lucie Canal Basins is a function of the relationships shown previously in Figure 2. During the rainfall-deficient winter and spring months the crops have their greatest plant-water requirements. Obviously, without some form of regional water storage system agricultural productivity would be significantly reduced. The amount of rainfall which is not converted to runoff in the EAA is effective for meeting crop water needs. Of the 49 inches of rain received by the EAA annually approximately 20 inches becomes runoff (data 1979 to 1988); which leaves an average of 29 inches of effective rainfall. Using the previously calculated evapotranspiration rate of 40 inches, this results in an average annual supplemental water need of 11 inches ( $40 \text{ ET} - 29 \text{ Peff} = 11 \text{ Irrigation}$ ). As a rough approximation this agrees remarkably well with the measured value of 10.3 inches per year.

A monthly distribution of usage is given in Table A1 in the Appendix. Applying the approach of using pan evaporation with a pan coefficient of 0.65 in the EAA and comparing the predicted use to the actual use in the dry seasons of 1970 to 1990 is shown in Figure 3, at right.



**Figure 3 - Actual vs. Estimated Use**

### **2. URBAN**

During a normal rainfall year the urban users of the Lower East Coast do not require supplemental water from Lake Okeechobee. Of particular note is the fact that the Lower East Coast receives an average annual rainfall of 59.2 inches, 10 inches per year more than the Everglades Agricultural Area. Additionally, the LEC receives significant wellfield recharge via easterly seepage out of the Water Conservation Areas. During prolonged drought periods, however, significant volumes from Lake Okeechobee can be required for LEC water use and to prevent saltwater intrusion into wellfields. As an example, from September 1988 to August 1989 over 300,000 acre-feet of water from the lake was required to be delivered to the Lower East Coast.

### **3. ENVIRONMENTAL**

Concerns over the quantity and quality of water deliveries to Everglades National Park and the Loxahatchee National Wildlife Refuge have led to both the passage of the Douglas Act and the establishment of criteria in a joint federal-state agreement. The Water Conservation Areas receive about 1,000,000 acre-feet per year of runoff from the Everglades Agricultural Area. The proposed installation of Best Management Practices in the next five years to remove nutrients from stormwater may reduce annual runoff volumes by as much as 20%. Consequently, a future environmental supplemental water requirement of about 200,000 acre-feet should be considered in future modifications to the Supply-Side Management Plan.

#### **E. SUPPLIES AND STORAGE**

The available supplies of water for use consist of the surface sources: Lake Okeechobee and the Water Conservation Areas; and the groundwater sources: the multi-level aquifer systems along the east and west coasts. During an extended drought the supply source of significance is Lake Okeechobee. Of all the available sources Lake Okeechobee appears to be the only reliable source for sequential multi-year storage and retrieval. The management of the water in the lake during rainfall-deficient periods is one of the most critical elements in minimizing adverse effects on people, industry and the environment. The next section will discuss the importance and function of the lake in relation to the overall water management goals of water supply, flood control and environmental enhancement.

### **III. LAKE OKEECHOBEE**

#### **A. RESERVOIR**

Lake Okeechobee is at the center of the Central and Southern Florida Flood Control Project which was designed and constructed by the U.S. Army Corps of Engineers. Due to its size, 730 square miles, the reservoir storage capacity of the lake is enormous. The lake receives significant volumes of runoff from the Kissimmee River and the Upper Chain of Lakes, Lake Istokpoga and numerous small inflows along the north shore in the wet season. During extended drought periods very little runoff is generated in the dry season from these areas. The lake has regulated control levels that establish the maximum safe storage considering the tropical nature of storms in south Florida during the late summer. From an environmental standpoint it is not healthy for the lake to reach these maximum levels very frequently because of the undesirable impacts on the littoral zone vegetation due to prolonged inundation.



The maximum stage of the regulated schedule is 17.5' NGVD, which would correspond to a storage volume in the lake of 5,106,000 acre-feet. The lowest level at which water can be removed from the lake for water supply purposes has been established at 9.5' NGVD, due to the downstream physical limitations. At a stage of 9.5' NGVD the lake still has an estimated 1,884,000 acre-feet of water which is considered inaccessible for water use. Therefore, the maximum available reservoir storage at 17.5' NGVD would be 3,222,000 acre-feet.

## B. MANAGEMENT ZONES

The upper limit of safe storage in Lake Okeechobee is called the Regulatory Schedule. The Regulatory Schedule has been modified over the years with the current favored proposal called "Run 25." The current Regulatory Schedule has a maximum 15.5' NGVD to 17.5' NGVD zone. Whenever the stage reaches or exceeds this level the Corps of Engineers initiates maximum discharges out of the lake, through the Caloosahatchee and St. Lucie Rivers. Under these conditions the downstream impacts on the estuaries are substantial. As a result attempts to limit damages are implemented in advance of reaching this level through an early release program.

The management of water levels and releases during dry periods is determined by a set of water shortage management zones as shown in Figure 4.

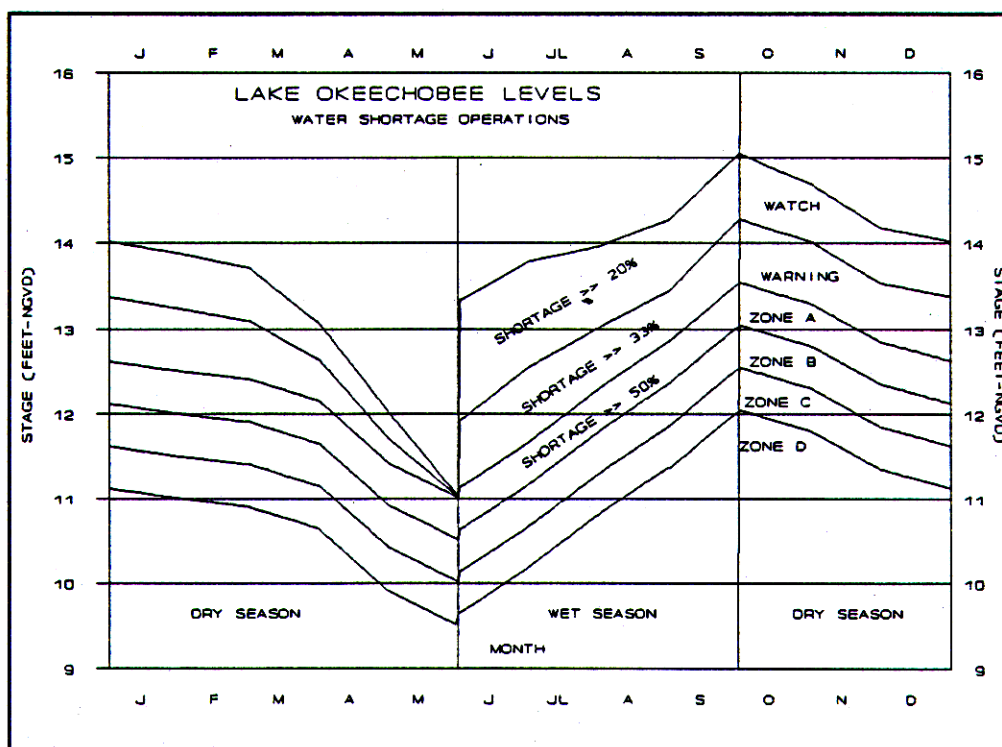


Figure 4 - Management Zones

The upper limit of Zone A represents a storage amount sufficient to meet all demands in the following year provided that all basins receive at least 100% of normal rainfall during the year. Each of the zones represent storage levels with assigned probabilities of shortage. For example, if the lake stage is in the Watch Zone in the summer, the South Florida area has a probability of a 20% to 33% chance of a water shortage in the following winter and spring. Accordingly, if the stage in the wet season is in Zone A or lower, the area has greater than a 50% chance of shortage in the following dry season.

### C. SERVICE AREA

The area served by Lake Okeechobee consists of five distinct sub-basins. They are the North Shore, Caloosahatchee, St. Lucie, the Everglades Agricultural Area and the Lower East Coast. The Supply-Side Management Plan uses an estimate of the irrigated acreage for each of these basins except the Lower East Coast. The reason that the Lower East Coast and the FP&L Indiantown Reservoir are excluded is due to the fact that almost all water usage from the lake is agricultural. An exception to this is the requirement to occasionally release some water down the Caloosahatchee River to reduce salinities at the raw water intakes in Ft. Myers. The size of the irrigated acreage is shown in Table 1.

Table 1 - Lake Okeechobee Service Area Basins

BASIN	IRRIGATED ACREAGE
North Shore	13,380
Caloosahatchee River	148,488
St. Lucie River	90,317
Everglades Agricultural Area	603,546
Total	855,731

### IV. WATER SHORTAGE PLAN

The Water Shortage Plan was implemented by the District in 1982 following one of the most severe droughts on record. During the 1980-82 drought Lake Okeechobee reached its all-time record low level of 9.75'NGVD. The plan provides specific guidelines for water restrictions which are based on the type of use and severity of the drought. Included within the plan are water use reductions which range from 15% to as much as 60% of estimated need. The required water use restrictions in the Lake Okeechobee Service Area are assumed to have been met when users comply with the Supply-Side Management Plan. To date the specific water use restrictions of the Water Shortage Plan have been invoked three times: 1982, 1985, and 1989.

## V. SUPPLY-SIDE MANAGEMENT

### A. PHILOSOPHY AND CONCEPTS

The driving philosophy behind this plan is a "live within our means" concept. Specifically, it requires that water is prudently budget, saved and distributed according to needs during water short periods. A recent amendment to this original concept is the year-round implementation of Supply-Side Management in parallel with the permanent day-time sprinkling bans in urban areas. Since the initial concept of Supply-Side Management was for dry season allocations it is easiest to describe these early concepts in terms of dry season factors. In its most succinct form:

**Supply-Side Management states that the amount of water available for use this period is a function of the anticipated rainfall, lake evaporation and water needs for the balance of the dry season in relation to the amount currently in storage.**

It is therefore important that several factors be estimated each period in order to compute the water availability. The rainfall, evaporation and water uses incorporated in the method are the normal values that can be expected over the balance of the dry season. The temporal variability of these factors is included in the computation of weekly allocations. An important element in the allocation methodology is that evaporation is greater than rainfall during the dry season, and water use in the spring is greater than the water use in the winter.

### B. HISTORIC APPLICATION

Lake Okeechobee Supply-Side Management has been implemented twice, first in 1981 and most recently in 1989. The original methodology was developed by Joseph Schweigart in response to the extremely low lake levels of 1981 and the concerns of continued drought. The assumptions of the original plan were: 1) that the minimum lake stage at the end of the dry season should not be allowed to fall below 11.0' NGVD; 2) that for computational purposes normal rainfall, normal evaporation and normal agricultural water use demands would be utilized; and 3) establish a stage of 13.5' NGVD on October 1 as being the level which must be exceeded in order to defer implementation of supply-side management techniques. Incorporated in this plan was an adjustment to the current allocation, termed "borrowing", wherein the users could borrow from their future supply, which is held in reserve by supply-side management, for use early in the dry season. This "borrowing" provision placed the decision of risk on the user in that the amount borrowed was mathematically subtracted from later months' allocations. Interestingly, the borrowing by the users in the early part of the 1981-82 dry season was offset by above normal rainfalls in the spring of 1982. In 1981-82 the allocations were made on a monthly basis with the computations performed monthly. A drawback to this, however, resulted from the once-a-month procedure not being reflective of dramatic precipitation events and associated supply and demand changes.

## **C. COMPUTATION PROCEDURES**

### **1. DRY SEASON**

The computation procedure at its highest level is for a dry season allocation amount which is presented as an available percentage of normal demand. The computation is:

#### **ASSUME:**

October 1st Water Level is 13.00' NGVD

June 1st Target Level is 11.00' NGVD

#### **APPLY STORAGE VOLUMES:**

Storage @13.00 = 3,108,000 Acre-feet

Storage @11.00 = 2,366,000 Acre-feet

#### **AVAILABLE SUPPLY:**

3,108,000 AF minus 2,366,000 AF = 742,000 AF

#### **LESS REDUCTIONS OF EVAPORATION:**

Rainfall minus Evaporation = -302,423 AF

#### **WATER ALLOCABLE:**

742,000 AF - 302,423 AF = 439,577 AF

#### **PERCENT OF NORMAL USE:**

439,577 AF / 663,351 AF = 66%

As can be seen in this case, the amount of water in storage which can be allocated to meet total dry season demands would be 439,577 acre-feet or about 66% of the normal requirements. The most simplistic perspective would indicate a need for a 33% water use cutback in order to equitably meet user demands. As can be seen above, the computation procedure is extremely simple, logical and straightforward. This has the advantage of being easily understood by all users when presented in this format.

### **2. MONTHLY ALLOCATIONS**

Since demands are not evenly spaced throughout the dry season, a simple linear interpolation per month would inappropriately distribute the supply and would not synchronize with the periods of need. Therefore, individual monthly variations of the key parameters must be considered and incorporated into the allocation methodology. As an example a case study is presented herein. The case will utilize a starting stage of 13.00' NGVD. This will be used throughout the analysis to provide consistency of understanding and transferability of concepts. The monthly distribution of rainfall and evaporation factors was determined by running the South Florida Regional Routing Model with an initial stage of 13.00' NGVD on October 1 and the assumption of normal precipitation and other climatic conditions for the balance of the dry season.

Table 2 provides the dry season monthly distribution, in volumetric terms, of the rainfall on Lake Okeechobee, the evaporation loss from the lake and the distribution of normal demands for water use from the lake.

**Table 2 - Monthly Distribution of Hydrologic Factors**

MONTH	RAINFALL (AF)	EVAPORATION (AF)	WATER USE (AF)	WATER USE (% OF TOTAL)
OCTOBER	89,472	126,720	52,402	7.9%
NOVEMBER	66,917	118,203	68,135	10.3%
DECEMBER	76,702	96,999	73,548	11.1%
JANUARY	88,589	104,599	53,115	8.0%
FEBRUARY	105,900	119,551	54,751	8.3%
MARCH	120,991	171,687	84,581	12.7%
APRIL	97,898	207,259	143,108	21.6%
MAY	232,277	236,151	133,711	20.1%
TOTAL	878,746	1,181,169	663,351	100.0%

In accordance with the previous dry season computation which showed an available supply of 66% of normal demand, the allocation amount for the month of October would be 34,585 acre-feet (52,402 AF times 66% = 34,585 AF). For subsequent months the amount of the allocation would be tied to the level of the lake at the beginning of the month more so than this overall dry season computation. As an example, assume that the lake declines by one-half foot during October to begin November at a stage of 12.50' NGVD. The November allocation amount would be calculated as follows:

**ASSUME:**

November 1st Water Level is 12.50' NGVD  
June 1st Target Level is 11.00' NGVD

**APPLY STORAGE VOLUMES:**

Storage @12.50' NGVD = 2,915,000 Acre-feet  
Storage @11.00' NGVD = 2,366,000 Acre-feet

**AVAILABLE SUPPLY:**

2,915,000 AF minus 2,366,000 AF = 549,000 AF

**LESS REDUCTIONS OF EVAPORATION:**

Rainfall minus Evaporation = -265,175 AF



**WATER ALLOCABLE:**

$$549,000 \text{ AF} - 265,175 \text{ AF} = 283,825 \text{ AF}$$

**REMAINING DRY SEASON NORMAL DEMAND:**

$$663,351 \text{ AF} - 52,402 \text{ AF (October)} = 610,949 \text{ AF}$$

**PERCENT OF NORMAL USE:**

$$283,825 \text{ AF} / 610,949 \text{ AF} = 46\%$$

Due to unanticipated declines in storage during October the available storage is only sufficient to meet 46% of normal demands. Therefore, the allocation amount for the month of November would be 31,342 acre-feet (68,135 AF times 46% = 31,342 AF).

In order to be clear on this procedure another calculation is presented below. However in this case it is assumed that above normal November rains have caused the lake to increase from 12.50' NGVD on November 1st to 12.75' NGVD on December 1st:

**ASSUME:**

December 1st Water Level is 12.75' NGVD

June 1st Target Level is 11.00' NGVD

**APPLY STORAGE VOLUMES:**

Storage @12.75' NGVD = 3,011,000 Acre-feet

Storage @11.00' NGVD = 2,366,000 Acre-feet

**AVAILABLE SUPPLY:**

$$3,011,000 \text{ AF} \text{ minus } 2,366,000 \text{ AF} = 645,000 \text{ AF}$$

**LESS REDUCTIONS OF EVAPORATION:**

$$\text{Rainfall minus Evaporation} = -213,889 \text{ AF}$$

**WATER ALLOCABLE:**

$$645,000 \text{ AF} - 213,889 \text{ AF} = 431,111 \text{ AF}$$

**REMAINING DRY SEASON NORMAL DEMAND:**

$$610,969 \text{ AF} - 68,135 \text{ AF (November)} = 542,834 \text{ AF}$$

**PERCENT OF NORMAL USE:**

$$431,111 \text{ AF} / 542,834 \text{ AF} = 79\%$$

This calculation demonstrates the responsiveness of the method to changes in storage and rainfall. The December allocation would be 58,103 acre-feet (73,548 AF times 79% = 58,103 AF). As this procedure shows, reducing the time step between computations improves the responsiveness of the allocations. As a result the selected time step in Supply-Side Management is weekly.

## **D. ALLOCATION FACTORS**

### **1. NORMAL MONTHLY**

An alternative computation approach is to prorate the available supply as a function of the remaining normal monthly distribution. In the above example the normal December usage is 73,548 acre-feet; the remaining normal dry season usage is 542,834 acre-feet; and hence, the percentage of remaining use represented by December is  $73,548 \text{ AF} / 542,834 \text{ AF} = 13.5\%$ . Also the computed allocation for December is 58,103 acre-feet which is also 13.5% of the available supply of 431,111 acre-feet. For ease of computation this proportion can be designated as a monthly allocation factor. Hence the allocation factor for December would be 0.135, which would be applied to the available storage on December 1 to determine the allocation for the month. The normal monthly allocation factors are shown in Table 3.

Table 3 - Normal Monthly Allocation Factors

MONTH	NORMAL USE (AF)	REMAINING USE (AF)	USE AS PERCENT OF REMAINING (%)	ALLOCATION FACTOR
OCTOBER	52,402	663,351	7.9%	0.079
NOVEMBER	68,135	610,949	11.1%	0.111
DECEMBER	73,548	542,814	13.5%	0.135
JANUARY	53,115	469,266	11.3%	0.113
FEBRUARY	54,751	416,151	13.2%	0.132
MARCH	84,581	361,400	23.4%	0.234
APRIL	143,108	276,819	51.7%	0.517
MAY	133,711	133,711	100.0%	1.000

### **2. BORROWED MONTHLY**

The users can choose to increase their use above the normal computed allocation by borrowing from future allocation amounts. The strategy allows for the borrowing of future amounts in 1/3 monthly increments, approximately four months in advance. As an example, users could borrow 1/3 of February's allocation in October, 1/3 of March's allocation in November, etc. up to 1/3 of May's allocation in January. When a borrowed amount is approved the monthly allocation factors must be recomputed to reflect the new monthly distribution which will be followed. A new concept developed in 1989 is that of "returning" borrowed water if climatological conditions allow. Returning of borrowed water would occur when a user agreed to use less than the allocated amount by the amount previously borrowed. When water is returned to the system, the monthly allocation factors must be recomputed. For an example of borrowing, assume that the users have determined that the previously computed November allocation of 31,342 acre-feet is not sufficient to meet their needs in November and request to borrow 1/3 of March's allocation. The recomputation of the remaining allocation factors provides the mechanism for determining the new borrowed allocation amount for November.

The computation involves shifting 28,194 acre-feet from March to November and recomputing the factors as shown in Table 4.

Table 4 - Allocation Factors - November Borrowing

MONTH	NORMAL USE (AF)	BORROWED USE (AF)	REMAINING USE (AF)	PERCENT REMAINING	ALLOCATION FACTORS
OCTOBER	52,402	52,402	663,351	7.9%	0.079
NOVEMBER	68,135	96,329	610,949	15.8%	0.158
DECEMBER	73,548	73,548	514,620	14.3%	0.143
JANUARY	53,115	53,115	441,072	12.0%	0.120
FEBRUARY	54,751	54,751	387,957	14.1%	0.141
MARCH	84,581	56,387	333,206	16.9%	0.169
APRIL	143,108	143,108	276,819	51.7%	0.517
MAY	133,711	133,711	133,711	100.0%	1.000

The new allocation amount for November under this borrowing scheme would be 44,844 acre-feet (0.158 times 283,825 AF (which was the November 1st computed allocable water) = 44,844 AF). This borrowing brought the monthly allotment for November back up to 66% of normal which was the total dry season percentage computed on October 1st.

### 3. NORMAL WEEKLY

The manner of allocation which appears to have been most helpful for irrigation planning is the weekly allocation. By computing allocations on a weekly basis the amounts are more responsive to user needs as well as more reflective of short-term fluctuations in storage and precipitation. The method for computing the weekly allocation factors is identical to the previously described procedure for monthly values. An example of a weekly allocation factor distribution is included in Table 5, the normal distribution of factors for the 1990/91 dry season.

Using this distribution the allocation for the first week of the 1990/91 dry season, the week of October 3rd, would be 7,715 acre-feet. This is computed by multiplying the allocation factor for week number 1 (0.017551) times the dry season allocation of 439,577 acre-feet. These number are approximate since week number 1 did not start on October 1 which is when the allocable water computation was made. In practice, the allocable water computation is made each week on Wednesday, which is the day of the week selected by the agricultural users for convenience of irrigation planning.

Table 5 - Normal Weekly Allocation Factors 1990/91

MONTH	DAY	WEEK NO.	NORMAL USE (ACRE-FEET)	ALLOCATION FACTOR
OCTOBER	3	1	11,833	0.017551
	10	2	11,833	0.017865
	17	3	11,833	0.018190
	24	4	11,833	0.018527
	31	5	15,898	0.025362
NOVEMBER	7	6	15,898	0.026022
	14	7	15,898	0.026717
	21	8	15,898	0.027450
	28	9	16,405	0.029125
DECEMBER	5	10	16,608	0.030369
	12	11	16,608	0.031320
	19	12	16,608	0.032333
	26	13	15,289	0.030761
JANUARY	2	14	11,994	0.024896
	9	15	11,994	0.025532
	16	16	11,994	0.026201
	23	17	11,994	0.026906
	30	18	13,446	0.030998
FEBRUARY	6	19	13,688	0.032565
	13	20	13,688	0.033661
	20	21	13,688	0.034834
	27	22	18,326	0.048320
MARCH	6	23	19,099	0.052915
	13	24	19,099	0.055872
	20	25	19,099	0.059178
	27	26	25,224	0.083075
APRIL	3	27	33,392	0.119937
	10	28	33,392	0.136282
	17	29	33,392	0.157785
	24	30	32,935	0.184782
MAY	1	31	30,193	0.207794
	8	32	30,193	0.262298
	15	33	30,193	0.355561
	22	34	30,193	0.551736
	29	35	24,530	1.000000
TOTAL			674,184	

To illustrate the inputs and outputs which are generated each week during the dry season, the week of January 9, 1991 has been selected as an example. On that date the stage of Lake Okeechobee was 12.22' NGVD:

**ASSUME:**

January 9th Water Level is 12.22' NGVD

June 1st Target Level is 11.00' NGVD

**APPLY STORAGE VOLUMES:**

Storage @12.22 = 2,806,920 Acre-feet

Storage @11.00 = 2,366,000 Acre-feet

**AVAILABLE SUPPLY:**

2,806,920 AF minus 2,366,000 AF = 440,920 AF

**LESS REDUCTIONS OF EVAPORATION:**

Rainfall minus Evaporation = -189,069 AF

**WATER ALLOCABLE:**

440,920 AF - 189,069 AF = 251,851 AF for dry season

251,851 AF times 0.025532 = 6,430 AF for week No. 15

**PERCENT OF NORMAL USE:**

6,430 AF / 11,994 AF = 54%

A table of weekly rainfalls, evaporation volumes, normal use and allocation factors for the 1990/91 dry season is included as Table A3 in the Appendix. The manner in which this weekly allocation is distributed to the users is via controlled outlets in the dike which surrounds Lake Okeechobee. These outlets are controlled and operated by the U.S. Army Corps of Engineers. Each week the operations staff of the District computes the requisite gate settings for each of the outlets and informs the Corps, who then make the changes. A listing of the control outlet structures and the irrigated acreage served by each is given in the Table 6. The geographic locations of the outlet structures and the individual sub-basins are included in the Appendix.



**Table 6 - Sub-basin Irrigated Acreage And Control Structure**

<b>SUB-BASIN</b>	<b>ACREAGE</b>	<b>CONTROLLED BY STRUCTURE</b>
ST. LUCIE	81,054	S-308
CULVERT 16	320	C-16
L-8	9,263	C-10A
WEST PALM BEACH CANAL	124,352	S-352
N. NEW RIVER & HILLSBORO	269,236	S-351
MIAMI CANAL	134,540	S-3/SIPHON
PELICAN LAKE WCD	1,600	C-13
EAST SHORE WCD	8,500	C-12
SOUTH SHORE WCD	4,430	C-4A
EAST BEACH WCD	7,000	C-10
S.FL. CONSERVANCY UNIT 5	9,775	2-36" PIPES
TOWNSITE U.S. SUGAR	8,960	2-33,000 GPM PUMPS
S-169	34,833	S-169
S-131	2,773	S-131
S-129	2,813	S-129
S-127	519	S-127
S-135	7,275	S-135
C-19 NORTH OF S-47B	7,830	C-5A
CALOOSAHATCHEE	140,658	S-77
<b>TOTAL</b>	<b>855,731</b>	

#### **E. OTHER FACTORS**

The target water level for these computations is 11.00' NGVD on June 1st. As previously discussed, it is possible to withdraw water from the lake as low as 9.75' NGVD. The volume of water between 11.00' NGVD and 10.0' NGVD, approximately 327,000 acre-feet, is reserved for the purpose of preventing salt-water intrusion in the Lower East Coast wellfields. If some of this water is required throughout the dry season by the Lower East Coast then the Target Level on June 1st can be lowered an equivalent amount in order to balance the distribution among all of the users. For example, if 80,000 acre-feet of water is required by the LEC in March then the June 1st target level could be lowered to 10.75' NGVD, since the storage differential in the lake between 11.0' NGVD and 10.75' NGVD is approximately 80,000 acre-feet. The new target of 10.75' NGVD would then be used for computation of April and May allocation amounts. The lowering of the target and the approval of borrowing is part of the decision-making process of the District's Water Shortage Management Team.

## **VI. SUMMARY**

The computation of the allocation amounts for water use under the Lake Okeechobee Supply-Side Management Plan is straightforward but can become complex when performed at its most responsive, weekly level. The purpose of the plan is to ensure that adequate water is held in reserve for later, high-demand periods and yet be responsive to the immediate short-term needs of the users who depend upon the lake as a primary water source. Supply-Side Management was designed to complement the District Water Shortage Plan by providing a means for the prudent management of surface water storage in Lake Okeechobee.

## **APPENDIX**

TABLE A1 - EVERGLADES AGRICULTURAL AREA RAINFALL AND WATER USE

MONTHLY VALUES IN INCHES

YEAR	JAN		FEB		MAR		APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC	
	RAIN	USE	RAIN	USE	RAIN	USE	RAIN	USE	RAIN	USE	RAIN	USE	RAIN	USE	RAIN	USE	RAIN	USE	RAIN	USE	RAIN	USE	RAIN	USE
1962	1.33	0.55	0.85	0.81	3.1	1.18	2.82	0.62	2.83	1.09	11.26		8.6		8.26		11.46		3.26		1.17	0.36	0.27	1.08
1963	1.05	0.62	3.60	0.14	0.81	1.22	0.40	2.72	6.95	0.75	6.14		2.50		7.86		6.00		1.43		2.26	0.45	4.82	0.6
1964	2.07	0.21	2.37	0.42	2.35	0.81	3.15	1.28	3.11	1.54	7.87		6.75		7.47		5.12		8.05		0.88	0.28	2.63	0.31
1965	0.33	1.23	3.15	0.47	2.78	0.83	0.99	2.23	1.38	3.13	9.81		9.95		6.74		5.77		7.74		0.45	0.53	1.19	1.32
1966	4.43	0.27	2.37	0.49	0.94	1.25	2.72	1.69	4.06	1.5	15.63		7.68		8.13		6.10		4.43		0.26	1.44	0.65	2.28
1967	1.08	1.69	3.53	0.8	0.81	2.08	0.02	3.87	1.48	3.52	11.84		8.13		5.28		6.70		4.47		0.14	2.19	2.00	1.66
1968	0.58	1.14	3.06	0.7	1.30	0.58	1.55	2.09	8.98	0.57	14.53		8.95		4.98		7.33		6.84		1.82	0.48	0.09	1.71
1969	1.84	0.73	1.70	1.21	5.20	0.86	2.84	1.99	5.51	1.15	10.92		6.10		7.47		6.75		7.32		2.42	0.06	1.63	0.15
1970	3.19	0.78	2.19	0.55	13.14	0.17	0.20	1.7	7.21	3.14	6.87		7.47		6.33		4.62		2.97	1.00	0.12	2.10	0.23	2.30
1971	0.65	1.40	1.57	0.70	0.46	1.80	0.19	2.40	5.14	0.90	9.63	0.30	8.07	0.00	6.11	0.10	6.87	0.00	5.98	0.30	2.74	0.70	1.40	1.10
1972	1.42	0.60	1.64	0.60	3.65	1.20	5.05	0.80	6.57	0.00	9.44	0.10	4.89	0.30	5.88	0.60	2.86	0.20	1.55	1.80	2.86	0.70	1.73	0.60
1973	2.38	0.20	1.31	0.10	2.40	0.60	0.61	2.10	4.45	2.10	6.64	0.40	8.88	0.00	7.58	0.00	6.15	0.00	2.37	0.70	0.18	2.90	2.10	1.10
1974	1.13	0.20	0.15	1.30	0.52	1.90	1.24	2.10	4.12	1.90	12.59	0.20	10.00	0.00	6.74	0.00	6.88	0.00	1.27	0.60	2.07	2.30	1.16	0.90
1975	0.14	1.30	0.81	1.70	0.80	2.80	1.47	3.80	6.08	1.40	8.76	0.10	9.47	0.00	4.89	0.00	10.04	0.00	3.84	0.00	1.04	0.80	0.27	2.10
1976	1.10	1.10	2.12	0.90	1.00	0.80	1.50	2.50	8.35	0.30	5.65	0.00	4.90	0.00	6.44	0.00	6.94	0.00	0.68	1.50	1.83	1.50	1.76	0.70
1977	3.21	0.10	0.77	0.50	0.61	1.90	0.49	2.80	9.10	1.10	5.81	0.60	5.38	0.30	6.76	0.20	8.81	0.00	0.82	1.30	5.54	0.50	4.61	0.00
1978	2.46	0.00	1.72	0.20	2.12	0.60	1.53	2.10	6.63	0.80	6.71	0.40	9.03	0.00	8.34	0.00	4.60	0.00	3.96	0.10	2.92	0.40	4.25	0.50
1979	3.53	0.40	0.29	1.40	2.02	1.40	2.44	2.20	3.88	0.80	3.60	4.30	4.80	0.80	4.12	0.20	8.68	0.00	1.94	0.10	3.93	0.00	2.19	0.20
1980	3.93	0.90	1.41	0.10	2.49	0.50	5.31	0.20	4.95	1.50	3.44	2.60	6.20	0.80	5.47	0.20	6.05	0.00	1.60	1.10	2.27	0.50	0.81	0.50
1981	0.50	0.90	2.10	0.30	1.61	1.00	0.15	2.80	3.14	2.30	4.76	1.20	4.66	1.40	12.77	0.10	4.42	0.10	1.05	0.80	3.81	0.50	0.22	1.10
1982	0.66	0.50	2.55	0.30	4.69	0.40	2.44	1.20	8.69	1.80	11.61	0.20	5.83	0.00	6.76	0.10	9.98	0.00	2.91	0.30	1.17	0.40	0.78	0.80
1983	3.89	0.40	7.45	0.00	4.52	0.00	1.76	0.70	1.56	3.60	9.71	0.00	4.07	0.60	7.23	0.00	6.76	0.20	6.30	0.10	1.17	0.40	4.06	0.40
1984	0.22	0.40	1.76	1.10	4.17	1.40	3.29	1.60	7.36	3.10	4.16	1.30	6.86	0.00	3.54	0.40	7.25	0.80	0.53	1.40	3.05	1.50	0.28	1.10
1985	0.71	1.50	0.11	1.50	1.85	1.80	5.33	0.80	2.50	2.30	7.09	2.20	9.60	0.10	6.19	0.00	9.09	0.00	5.48	0.20	1.79	0.40	2.15	0.40
1986	2.70	0.30	1.33	0.20	5.02	0.10	0.28	1.70	3.79	2.20	12.22	0.30	6.49	0.00	7.44	0.00	3.91	0.10	4.46	0.40	1.75	0.30	4.50	0.80
1987	1.77	0.20	1.32	0.20	5.66	0.10	0.21	1.70	2.58	2.20	5.78	3.30	6.90	0.10	4.42	0.60	4.98	0.20	3.45	0.2	8.46	0	0.43	0.3
1988	2.21	0.23	1.59	0.19	2.07	1.02	1.64	2.15	2.81	1.91	6.04	1.16	10.21	0.16	9.15	0.04	1.82	0.9	0.38	2.87	1.78	1.33	0.50	1.63
1989	0.78	1.11	0.27	1.84	2.27	1.55	3.76	2.04	1.53	4.05	5.01	2.86	5.50	0.68	6.89	0.4	8.75	0.02	3.08	0.01	0.68	1.59	1.76	0.46
1990	1.38	0.48	2.45	0.61	1.59	2.34	1.79	2.28	5.84	0.71	5.5	0.35	6.24	0.25	8.01	0.14	4.51	0.26	3.93	0.09	0.59	0.72	0.87	0.88
1991	8.17	0.37	2.59	0.8	1.54	0.81	4.98	0.43	5.92	1.45														
AVE	1.75	0.66	1.92	0.67	2.76	1.10	1.90	1.89	4.85	1.76	8.24	1.09	7.04	0.27	6.80	0.15	6.52	0.14	3.52	0.71	2.04	0.87	1.70	0.93

TABLE A2 - EVERGLADES AGRICULTURAL AREA PAN EVAPORATION AND EVAPOTRANSPIRATION

## MONTHLY VALUES IN INCHES

YEAR	OCTOBER PAN EVAP	NOVEMBER PAN EVAP	DECEMBER PAN EVAP	YEAR	JANUARY PAN EVAP	FEBRUARY PAN EVAP	MARCH PAN EVAP	APRIL PAN EVAP	MAY PAN EVAP	JUNE PAN EVAP	JULY PAN EVAP	AUGUST PAN EVAP	SEPTEMBER PAN EVAP
1962	5.02	3.00	2.85	1963	3.26	3.26	5.94	6.99	6.49	6.60	6.83	6.50	5.09
1963	5.35	3.86	3.17	1964	2.39	4.04	5.36	6.74	6.43	6.25	5.57	6.14	5.21
1964	4.34	3.28	3.13	1965	3.51	4.34	5.83	7.18	7.69	6.27	6.55	6.49	5.13
1965	4.66	3.53	3.16	1966	3.07	3.73	5.12	6.64	6.61	6.23	5.49	6.01	4.99
1966	3.92	3.94	3.13	1967	3.44	3.67	5.84	7.39	7.87	5.54	7.11	6.11	5.90
1967	4.78	3.80	3.44	1968	3.22	4.16	6.24	6.79	6.52	5.45	6.44	5.61	5.21
1968	4.21	3.18	3.00	1969	2.86	3.89	4.73	5.43	5.95	5.84	6.39	5.98	4.76
1969	3.96	3.78	3.19	1970	3.17	3.60	5.42	6.44	7.35	6.43	6.30	6.41	5.71
1970	5.10	3.72	3.10	1971	3.43	4.41	6.50	7.23	8.24	6.65	6.78	5.92	4.72
1971	4.34	3.28	3.09	1972	3.21	3.73	5.64	6.21	6.09	5.56	5.89	5.20	4.82
1972	4.17	2.83	2.73	1973	3.15	3.40	5.79	6.54	7.25	6.36	5.18	4.45	4.08
1973	4.99	3.44	2.95	1974	3.07	4.47	5.59	6.10	6.63	5.36	5.54	5.50	4.80
1974	4.40	3.01	2.45	1975	3.14	3.69	5.03	5.94	6.32	5.64	5.43	6.52	5.18
1975	4.48	3.14	2.97	1976	3.35	3.51	5.32	6.18	6.37	5.24	5.76	5.28	5.13
1976	4.15	3.75	2.63	1977	3.99	3.78	5.39	6.63	8.63	7.97	7.67	7.79	6.50
1977	4.96	3.78	3.84	1978	3.44		5.66	7.13	7.28	6.42	6.66	6.22	5.82
1978	4.65	3.62	3.43	1979	3.46	4.07	5.61	6.62	6.75	7.65	7.20	5.72	4.94
1979	4.25	3.20	2.88	1980	3.32	3.68	5.58	6.21	6.89	7.19	7.16	6.43	4.91
1980	5.07	3.57	3.03	1981	3.63	4.25	6.14	6.72	8.09	7.06	7.52	5.58	5.42
1981	5.21	4.05	4.00	1982	3.83	4.75	5.71		7.53	6.34		6.89	5.24
1982	5.05	3.77	3.74	1983	3.37	4.34	5.85	7.06	8.53	7.03	7.25	6.88	5.85
1983	5.47	3.92	3.30	1984	3.84	4.78	7.29	7.62	7.95	7.13	6.63	7.95	6.80
1984	5.78	4.12	4.02	1985	4.21	5.37	6.98	7.09	8.58	7.46	6.52	6.38	5.91
1985	5.41	4.92	3.44	1986	4.22	5.08	6.32	7.79	7.70	5.34	7.22	5.94	5.71
1986	5.43	3.81	2.83	1987	3.63	3.79	4.90	7.16	7.26	7.12	6.56	7.25	5.46
1987	5.13	3.71	4.07	1988	3.07	3.93	5.93	7.61	7.04	6.07	6.16	5.52	5.95
1988	5.49	3.82	3.57	1989	3.98	4.67	5.74	7.09	7.94	7.16	6.72	5.83	5.44
1989	5.00	3.72	2.85	1990	4.45	5.00	5.92	6.44	7.02	6.30	6.92	6.79	5.53
AVE	4.96	3.69	3.26		3.59	4.04	5.84	6.47	7.40	6.55	6.24	5.91	5.15

YEAR	OCTOBER ET =PANx.65	NOVEMBER ET =PANx.65	DECEMBER ET =PANx.65	YEAR	JANUARY ET =PANx.65	FEBRUARY ET =PANx.65	MARCH ET =PANx.65	APRIL ET =PANx.65	MAY ET =PANx.65	JUNE ET =PANx.65	JULY ET =PANx.65	AUGUST ET =PANx.65	SEPTEMBER ET =PANx.65
1962	3.26	1.95	1.85	1963	2.12	2.12	3.86	4.54	4.22	4.29	4.44	4.23	3.31
1963	3.48	2.51	2.06	1964	1.55	2.63	3.48	4.38	4.18	4.06	3.62	3.99	3.39
1964	2.82	2.13	2.03	1965	2.28	2.82	3.79	4.67	5.00	4.08	4.26	4.22	3.33
1965	3.03	2.29	2.05	1966	2.00	2.42	3.33	4.32	4.30	4.05	3.57	3.91	3.24
1966	2.55	2.56	2.03	1967	2.24	2.39	3.80	4.80	5.12	3.60	4.62	3.97	3.84
1967	3.11	2.47	2.24	1968	2.09	2.70	4.06	4.41	4.24	3.54	4.19	3.65	3.39
1968	2.74	2.07	1.95	1969	1.86	2.53	3.07	3.53	3.87	3.80	4.15	3.89	3.09
1969	2.57	2.46	2.07	1970	2.06	2.34	3.52	4.19	4.78	4.18	4.10	4.17	3.71
1970	3.32	2.42	2.02	1971	2.23	2.87	4.23	4.70	5.36	4.32	4.41	3.85	3.07
1971	2.82	2.13	2.01	1972	2.09	2.42	3.67	4.04	3.96	3.61	3.83	3.38	3.13
1972	2.71	1.84	1.77	1973	2.05	2.21	3.76	4.25	4.71	4.13	3.37	2.89	2.65
1973	3.24	2.24	1.92	1974	2.00	2.91	3.63	3.97	4.31	3.48	3.60	3.58	3.12
1974	2.86	1.96	1.59	1975	2.04	2.40	3.27	3.86	4.11	3.67	3.53	4.24	3.37
1975	2.91	2.04	1.93	1976	2.18	2.28	3.46	4.02	4.14	3.41	3.74	3.43	3.33
1976	2.70	2.44	1.71	1977	2.59	2.46	3.50	4.31	5.61	5.18	4.99	5.06	4.23
1977	3.22	2.46	2.50	1978	2.24		3.68	4.63	4.73	4.17	4.33	4.04	3.78
1978	3.02	2.35	2.23	1979	2.25	2.65	3.65	4.30	4.39	4.97	4.68	3.72	3.21
1979	2.76	2.08	1.87	1980	2.16	2.39	3.63	4.04	4.48	4.67	4.65	4.18	3.19
1980	3.30	2.32	1.97	1981	2.36	2.76	3.99	4.37	5.26	4.59	4.89	3.63	3.52
1981	3.39	2.63	2.60	1982	2.49	3.09	3.71		4.89	4.12		4.48	3.41
1982	3.28	2.45	2.43	1983	2.19	2.82	3.80	4.59	5.54	4.57	4.71	4.47	3.80
1983	3.56	2.55	2.15	1984	2.50	3.11	4.74	4.95	5.17	4.63	4.31	5.17	4.42
1984	3.76	2.68	2.61	1985	2.74	3.49	4.54	4.61	5.58	4.85	4.24	4.15	3.84
1985	3.52	3.20	2.24	1986	2.74	3.30	4.11	5.06	5.01	3.47	4.69	3.86	3.71
1986	3.53	2.48	1.84	1987	2.36	2.46	3.19	4.65	4.72	4.63	4.26	4.71	3.55
1987	3.33	2.41	2.65	1988	2.00	2.55	3.85	4.95	4.58	3.95	4.00	3.59	3.87
1988	3.57	2.48	2.32	1989	2.59	3.04	3.73	4.61	5.16	4.65	4.37	3.79	3.54
1989	3.25	2.42	1.85	1990	2.89	3.25	3.85	4.19	4.56	4.10	4.50	4.41	3.59
AVE	3.23	2.40	2.12		2.33	2.62	3.80	4.20	4.81	4.26	4.06	3.84	3.35



TABLE A3 - NORMAL WEEKLY ALLOCATION FACTORS 1990/91

MONTH	DAY	WEEK NO.	EXPECTED NORMAL RAINFALL (ACRE-FEET)	EXPECTED NORMAL EVAPORATION (ACRE-FEET)	NEXT WEEK'S NORMAL USAGE (ACRE-FEET)	WEEKLY ALLOCATION FACTOR
OCTOBER	3	1	20,203	28,614	11,833	0.017551
	10	2	20,203	28,614	11,833	0.017865
	17	3	20,203	28,614	11,833	0.018190
	24	4	20,203	28,614	11,833	0.018527
	31	5	15,614	27,581	15,898	0.025362
NOVEMBER	7	6	15,614	27,581	15,898	0.026022
	14	7	15,614	27,581	15,898	0.026717
	21	8	15,614	27,581	15,898	0.027450
	28	9	16,832	23,525	16,405	0.029125
DECEMBER	5	10	17,320	21,903	16,608	0.030369
	12	11	17,320	21,903	16,608	0.031320
	19	12	17,320	21,903	16,608	0.032333
	26	13	18,087	22,393	15,289	0.030761
JANUARY	2	14	20,004	23,619	11,994	0.024896
	9	15	20,004	23,619	11,994	0.025532
	16	16	20,004	23,619	11,994	0.026201
	23	17	20,004	23,619	11,994	0.026906
	30	18	25,551	28,992	13,446	0.030998
FEBRUARY	6	19	26,475	29,888	13,688	0.032565
	13	20	26,475	29,888	13,688	0.033661
	20	21	26,475	29,888	13,688	0.034834
	27	22	27,200	37,499	18,326	0.048320
MARCH	6	23	27,321	38,768	19,099	0.052915
	13	24	27,321	38,768	19,099	0.055872
	20	25	27,321	38,768	19,099	0.059178
	27	26	25,402	42,879	25,224	0.083075
APRIL	3	27	22,843	48,360	33,392	0.119937
	10	28	22,843	48,360	33,392	0.136282
	17	29	22,843	48,360	33,392	0.157785
	24	30	27,072	49,070	32,935	0.184782
MAY	1	31	52,450	53,324	30,193	0.207794
	8	32	52,450	53,324	30,193	0.262298
	15	33	52,450	53,324	30,193	0.355561
	22	34	52,450	53,324	30,193	0.551736
	29	35	22,478	22,853	24,530	1.000000
TOTALS			877,580	1,176,524	674,184	

NOTE: Totals are slightly different from report due to weeks which straddle months.

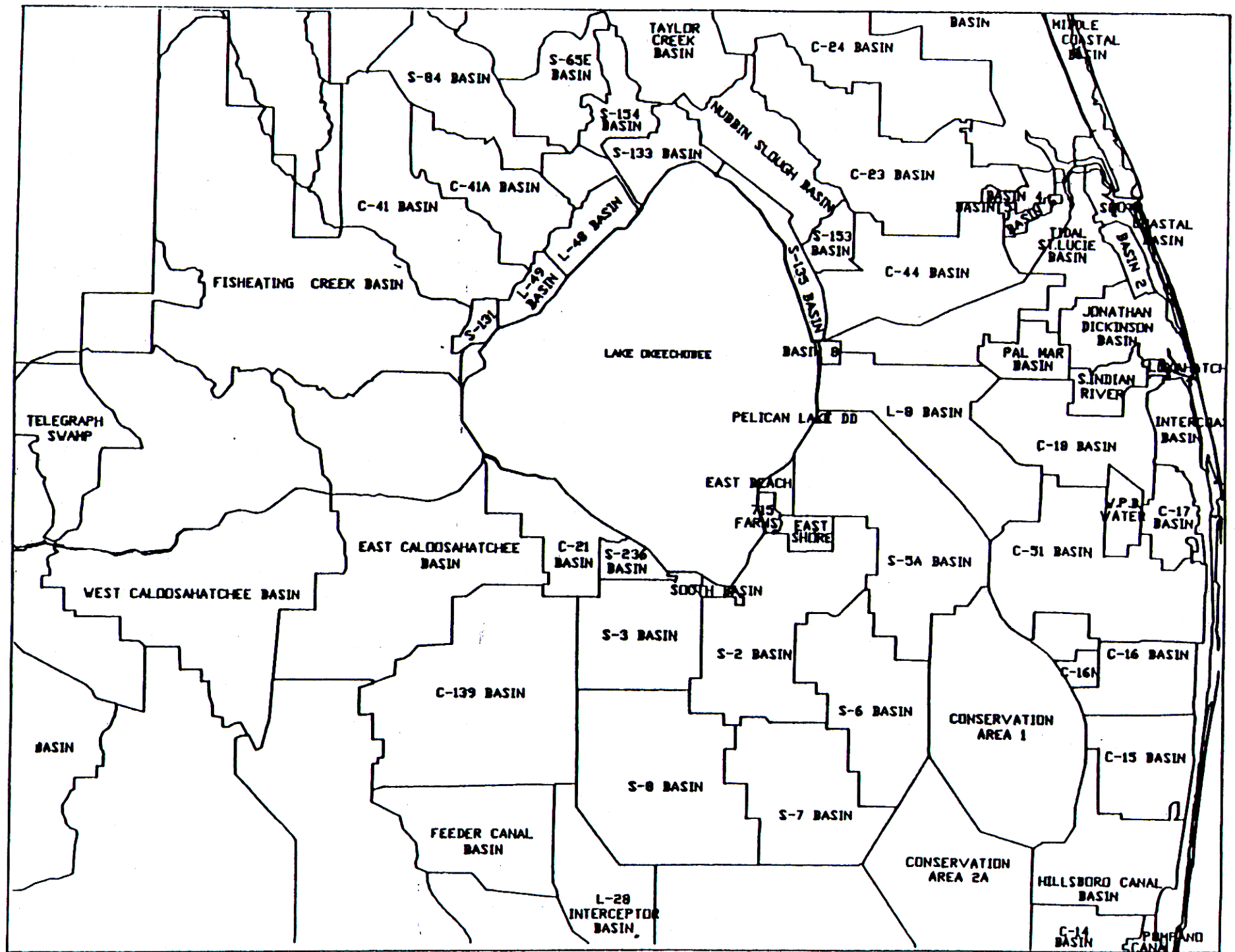
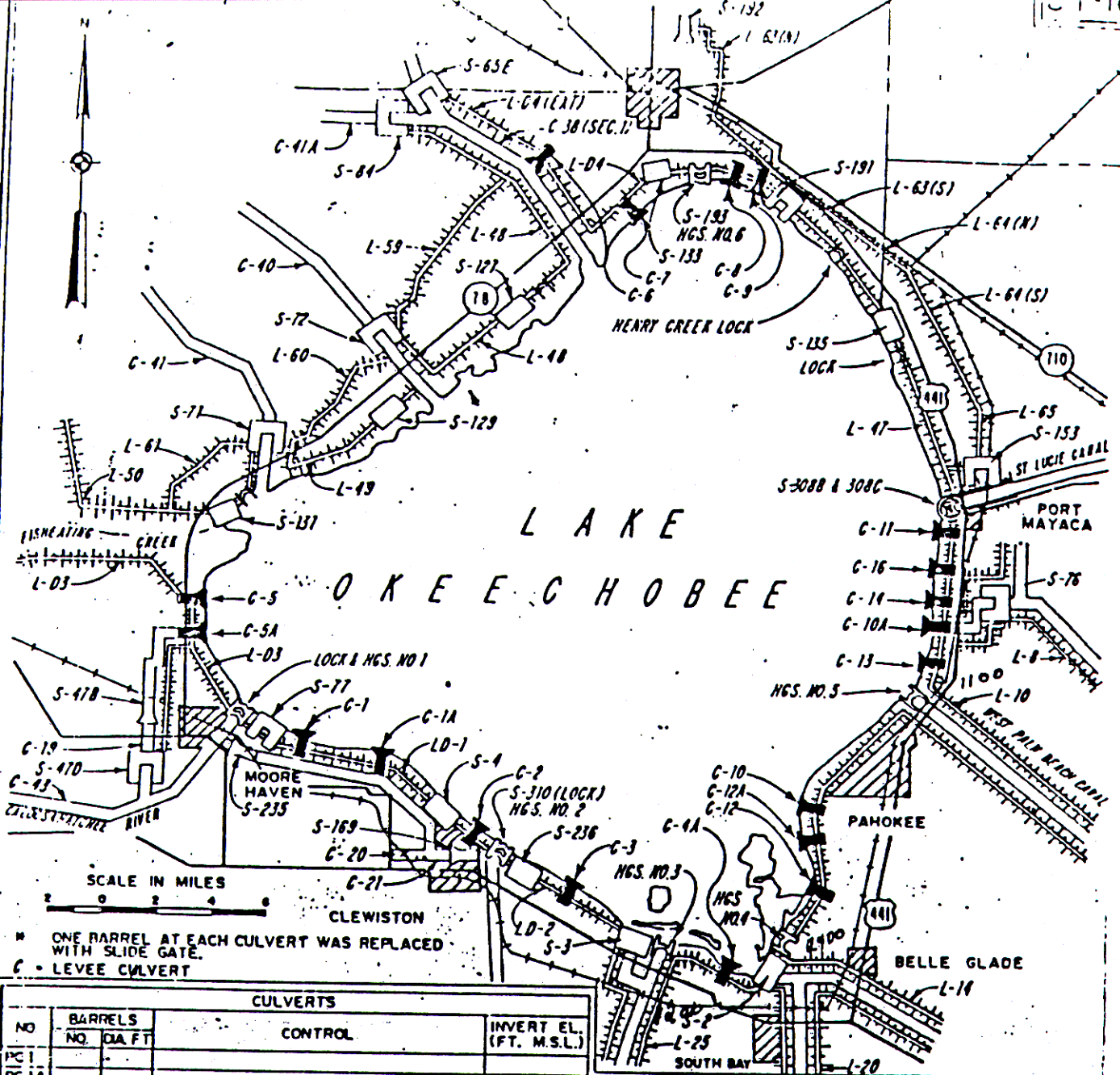


Figure A1 - Sub-Basin Boundaries



CULVERTS				
NO	BARRELS NO.	DIAM. FT.	CONTROL	INVERT EL. (FT. M.S.L.)
PC1				
PC1A				
1	2	10	PUMP / FLAP GATE	
1A	3	7	VERTICAL SCREW GATES / PUMP	
2	6	10	FLAP GATES	
3	2	10	PUMP / FLAP GATE	
4A	1	10	PUMP / SLIDE GATE	
H5	3	10	FLAP GATES	5.5
H5A	3	10	FLAP GATES	5.5
6	1	10	SLIDE GATES	5.4
H7	3	10	FLAP GATES	
H8	3	10	FLAP GATES	
H9	3	10	FLAP GATES	
H10	2	10	PUMP / FLAP GATES	5.5
H10A	5	10	FLAP GATES / <i>Slide gates</i>	5.5
11	1	10	PUMP / SLIDE GATES	7.2
H12	3	10	PUMP / FLAP GATES	5.5
12A	1	7	PUMP / SLIDE GATES	6.0
13	1	10	SLIDE GATE	5.5
14	1	10	SLIDE GATE	5.5
16	1	10	SLIDE GATE	5.5

LEGEND	
CANAL	=====
LEVEE	=====
SPILLWAY AND LOCK	=====
SPILLWAY	=====
CULVERTS	=====
PUMPING STATION	=====
HURRICANE GATE STRUCTURE	=====
LOCK	=====

CENTRAL AND SOUTHERN FLORIDA  
(FLOOD CONTROL AND OTHER PURPOSES)  
LAKE OKEECHOBEE  
LEVEE CULVERTS

DEPARTMENT OF THE ARMY  
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS  
JACKSONVILLE, FLORIDA  
9-30-78

Figure A2 - Lake Okeechobee Outlet Structures